SOLA Calculation of Viscous Fluid Flow

This plot shows how a viscous fluid is set in motion when the top wall of the container starts to move to the right. The fluid velocity vectors (**green** arrows) are shown at a number of grid points (black dots). The motion of the fluid is calculated using a flow code called SOLA.

SOLA is a Fortran program written in the 1970's by Tony Hirt and collaborators at the Los Alamos National Laboratory. It integrates the Navier-Stokes equations, the partial differential equations governing hydrodynamic flow of viscous fluids. SOLA is a relatively simple fluid dynamics code, being restricted to two-dimensional calculations. The two most common cases are *plane geometry* (parameter $\xi = 0$, coordinates x and y) and *cylindrical geometry* ($\xi = 1$, x now representing the radial coordinate ρ and y the axial coordinate z). For details regarding this simplified Marker-and-Cell (MAC) code, see Los Alamos Scientific Laboratory Report LA-5852 (1975).

The Navier-Stokes Equations, for those who do not know them by heart, are

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where the coefficient ξ specifies the geometry, as indicated above, and ν is the fluid's coefficient of kinematic viscosity. The velocity components u, v are in the coordinate directions x, y. Also, p is the ratio of the pressure to constant density and g_x, g_y are body accelerations (such as due to gravity). The third equation represents the conservation of mass in the flow process.

The numerical solution of these equations involves a finite difference method, integrating forward from time t = 0 in steps of size Δt, for given initial conditions at t = 0. For details, see the above-cited report.

The example presented here involves the following boundary conditions. It is planar geometry (ξ = 0), a long channel (in the z-direction) with a square cross-section in the x-y plane. There are confining walls at x = 0 and 1, the sides, and at y = 0 and 1, the bottom and top. At time t = 0 the top boundary wall impulsively starts to move to the right with velocity 1.0 (and continues to move in that direction indefinitely). This velocity v = 1.0 is arbitrary, i.e., it is not the speed of light or even the speed of sound in the fluid. The fluid is assumed to have viscosity ν = 0.2. Because of the sudden motion, the fluid (which was initially at rest) develops a swirling clockwise flow which rapidly approaches a steady state condition.

The SOLA code, which is in the public domain, can be used to attack other problems. The above-cited report also presents examples of fluid flow about a cylindrical can, flow of air (wind) over a recessed highway, and flow in a water-cooled power reactor.

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